

Moderate to Severe Traumatic Brain Injury From the Battlefield to the Community

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ABSTRACT

Traumatic brain injury (TBI) has been recognized as one of the signature injuries of recent warfare. Tactical combat casualty care (TCCC) plays an integral part in triaging and treating combat wounded troops including Special Operations Forces with TBI and other life threatening injuries. Patients with the most severe brain injuries require rapid evacuation from the battlefield to emergency medical centers capable of providing computerized tomography (CT) imaging, intracranial pressure (ICP) monitoring and ongoing neurological care. Medical treatment to manage brain injury is often provided in tandem with lifesaving surgery and immediate medical services for other injuries. Once stabilized, servicemen with TBI enter a continuum of care which extends across the globe. Joint military and VA trauma and rehabilitation teams work to ensure the best possible outcomes for patients with brain injury. Military and VA medical centers have established new systems of care to help treat increasing numbers of troops with TBI and community-based care and reentry programs help patients with moderate and severe TBI adjust to physical and cognitive changes allowing them to live meaningful and productive lives.

OBJECTIVES

TBI can significantly impact an individual's overall health and future independence. Special Operations medics are treating increasing numbers of troops with traumatic brain injury. The goal of this article is to provide a broad overview of TBI occurrence, treatment, and care within military and VA systems. Within this context, the authors describe several strategies for the assessment and management of moderate and severe TBI, with an emphasis on closed brain injuries and its occurrence on the battlefield. This includes resources to support a recovery trajectory as well as the continuum of care which supports critically wounded TBI patients who require comprehensive and intensive rehabilitation efforts. This information should not be viewed as a clinical practice guideline addressing all aspects of care, but rather as a general overview for medics and corpsmen who wish to increase their understanding of TBI. After reading this article, readers should be able to:

1. Describe important steps in assessing and managing acute TBI on the battlefield.
2. Describe the military and VA resources available to assist soldiers with TBI and their families.
3. Understand the potential outcome of acute TBI and its relationship to early diagnosis and treatment.

Future articles may further explore brain physiology and the techniques mentioned within and/or the identification and treatment of mild TBI which is an increasingly pervasive problem in military settings.

BACKGROUND

Traumatic brain injury (TBI) has been recognized as one of the signature injuries sustained by service members wounded in Afghanistan and Iraq.^{1,2} Understanding TBI assessment, treatment, and risk factors is essential for medics and corpsmen that operate in remote areas. Any delay in emergency treatment can reduce the chance for optimal recovery and survival following traumatic brain injury.

Once medically evacuated, services for patients with TBI include acute medical treatment, rehabilitation, and ongoing TBI care in community settings. These services are provided in part by clinicians at the Defense and Veterans Brain Injury Center (DVBIC) who work in partnership with military and VA polytrauma centers throughout the country. The DVBIC is a tri-service DoD/VA congressionally mandated organization that comprises three military treatment facilities (Walter Reed

Army Medical Center, Wilford Hall Medical Center, and National Medical Center San Diego), four VA poly-trauma centers (Minneapolis VA, Palo Alto VA, Richmond VA and Tampa VA), as well as two community reentry civilian facilities (Lakeview Virginia Neurocare and Laurel Highlands Rehabilitation Center). The DVBIC at Walter Reed Army Medical Center screens all medically evacuated service members from Iraq and Afghanistan who have been injured in explosions or other events known to cause head injury. The relatively large number of TBI patients seen at WRAMC may be the result of several factors, including careful screening, medical advances, and the rapid triage and transport evacuation system.²

TRAUMATIC BRAIN INJURY

Traumatic brain injury is defined as a blow, jolt, or other injury to the head that disrupts the functioning of the brain. A TBI occurs when an external force applied to the brain is significant enough to alter neurological functioning or consciousness. Previous studies on the residual effects of TBI resulting from combat, identified as early as World War II, focused on *penetrating* brain injuries which were a significant cause of morbidity at that time.³ Over the last 15 years, between 14 and 20% of surviving casualties of armed conflicts have sustained a TBI.^{4,5} While changing medical practices and varying research methodologies make it difficult to compare actual TBI rates with past wars, it is believed that a greater number of brain injuries, which occur in theatre today, can be categorized as closed TBI.²

The causes of brain injury in combat include exposure to blasts, falls, gunshot wounds and motor vehicle accidents. These mechanisms impact the brain with varying levels of force. The resulting injuries can be either localized

(confined to one area) or diffuse (impacting many areas of the brain). Individual physical characteristics combine with these varied mechanisms to yield unique sequelae which affect multiple systems. To help distinguish these effects, an initial classification is made between penetrating and closed brain injuries. Any injury which involves the penetration of a foreign object,

munitions fragment, bone chip, etc., through the dura mater, which covers the brain, is called a penetrating brain injury. Conversely, a brain injury that does not penetrate the dura is considered closed. The pathophysiology of closed TBI differs in many ways from penetrating TBI; however, the damage to the brain can be equally severe. The following classification system is used to determine the severity of injury related to blunt force trauma / closed TBI.

TBI SEVERITY INDICATORS

The severity of injury can be determined by comparing three indices: The overall Glasgow Coma Score (GCS); the length of loss of consciousness (LOC); and the amount of post traumatic amnesia (PTA). Though sometimes difficult to assess in an austere environment, this information can help to classify the severity of injury ranging from mild to moderate to severe. Mild TBI (mTBI) is characterized by a LOC of less than an hour, a period of posttraumatic amnesia that resolves within 24 hours, or a GCS score of 13 to 15.⁶ Moderate TBI is indicated by LOC that lasts between one and twenty-four hours, PTA for more than 24 hours (but less than seven days), or a GCS score between nine and twelve. A severe TBI is classified by LOC longer than 24 hours, PTA greater than seven days, or a GCS score between three and eight.⁷ When severity indicators are inconsistent, the most severe characterization is used. It is uncommon for all indices to be reported or available. Any one of them alone can qualify to assign severity of injury.

Severity of Traumatic Brain Injury Rating Scale:			
Severity	GCS	LOC	PTA
Mild	13 to 15	<1 hr	<24 hr
Moderate	9 to 12	1 to 24 hrs.	24 hrs. to <7days
Severe	3 to 8	>24 hrs.	7 days or more
GCS = Glasgow Coma Scale			
LOC = Loss of consciousness			
PTA = Posttraumatic amnesia			

Symptoms may vary between each level of severity. Mild cases of TBI are indicated by a brief change in mental status or consciousness which may be followed by temporary symptoms associated with concussion such as headache, dizziness, and memory problems. The symptoms of mild TBI generally resolve in a short period of time but require patients to limit their activity to prevent

further injury or harm to others. This is particularly true of military populations whose occupational activities are more rigorous and place them at greater risk of re-injury than civilian populations.

Moderate brain injuries are associated with longer periods of LOC or PTA which follow the traumatic event. Patients with moderate TBI may experience a variety of symptoms including mood and memory disturbances, and physical and emotional problems which may persist for months. Moderate TBI may require increased levels of medical intervention to allow patients to return to their maximal level of functioning. There is a greater incidence of disability among those with moderate brain injury than those with milder injuries.

A severe TBI most often results in long-term problems with independent functioning and can result in moderate to severe disability in some patients. Patients with severe brain injury have more significant impairments and thus the cognitive, physical, and emotional symptoms are more pronounced, may compound one another, and may complicate the delivery of needed treatment. Since severe TBI frequently occurs with other traumatic injuries, comprehensive nursing care and ongoing rehabilitation are usually required. Optimal recovery from severe TBI relies on early intervention, rapid evacuation, and ongoing specialized treatment in acute settings.

The complexity of severe TBI requires a multi-disciplinary approach to care. Neurology, psychiatry, neuropsychology, physical and rehabilitative medicine, and neurosurgery comprise the core disciplines needed for initial treatment of severe TBI. However, many ancillary services and therapies are required early on as well. Comprehensive care and rehabilitation can include physical therapy, occupational therapy, audiology, optometry, cognitive rehabilitation, behavioral therapy, and case management. The level of recovery from TBI is highly variable; however, prognostic indicators have been identified which help to guide clinical practice and recovery. While the long-term effects of acute brain injury may be significant, there is often potential for considerable improvement which allows patients with brain injury to lead meaningful and productive lives.

TBI SUSTAINED IN THE THEATRE OF OPERATIONS

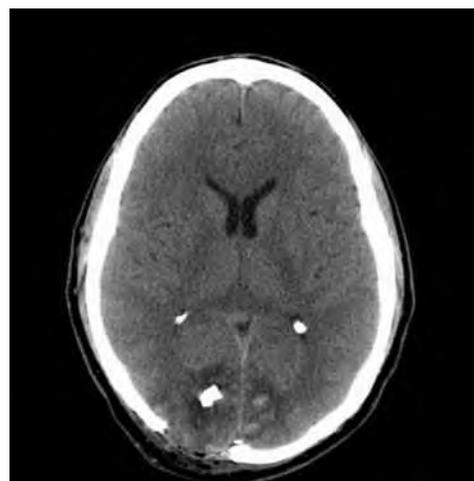
Improvements in protective body armor have reduced the threat of penetrating wounds; however, explosive attacks continue to place troops at high risk for traumatic brain injury. The blast itself can cause injury through multiple mechanisms. These mechanisms may include direct exposure to the over-pressure wave of the explosion which can impact the body at a velocity greater

than 300m per second, equal to the speed of sound in air, causing primary blast injury. This impact may rapidly compress air-filled organs and/or displace the entire body. Secondary blast injury may then be caused by the energized (projected or falling) debris or explosive fragments which impact with the head. Tertiary blast injury may also occur as the displaced body impacts the ground, a wall, or any other object. Finally quaternary injuries may occur through the inhalation of gases or other toxic substances.^{8,9} Individually, these mechanisms can compromise the brain resulting in significant physical, cognitive, and neuropsychiatric impairment. Together, they can cause severe TBI along with any number of other injuries such as burns, abdominal wounds, or limb amputation.

Special Operations Forces also share the risk of TBI associated with more traditional means of warfare as well. Motor vehicle accidents can result in blunt force trauma to the head in which the brain impacts the rigid interior of the skull. Gunshot wounds can be lethal although advances in helmet design are reducing the risk of penetrating injuries and increasing survivability when they do occur.

Unlike closed TBI, penetrating brain injuries occur when a projectile or fragment lacerates and destroys brain tissue. Bullets and other high-velocity objects create centrifugal forces and “shock waves” within the brain that can create a cavity many times greater than the diameter of the missile itself. Though this cavity is reduced in size once after the projectile transverses the brain, the tissue that was compressed during cavitation remains injured.¹⁰

Helmets outfitted with shock absorbing pads provide ballistic protection for the head by allowing room for cavitation caused by blast forces and projected fragments. More importantly, increased comfort makes it more likely



Head CT scan of penetrating brain injury. Lower white mass indicates intracranial bone fragment. Also visible is opening / skull fracture.

that the helmet will be worn and remain firmly on the head. The CT scan shown below illustrates a penetrating head wound caused by a bullet in which the missile velocity was reduced. Traumatic brain injury caused by blast and gunfire in which the head is unprotected is likely to be much more severe.

FORWARD MEDICAL ASSESSMENT AND TREATMENT OF ACUTE TBI

Tactical combat casualty care (TCCC) plays an integral part in triaging and treating combat wounded with life threatening injuries. Special Operation Forces may be at increased risk for sustaining critical injuries due to the high risk nature of their missions worldwide. The *Guidelines for the Field Management of Combat-Related Head Trauma*¹¹ were formulated to provide a best-evidence document to address the specific needs of assessing and managing head injury in an austere environment. The guidelines address three main areas: assessment, treatment, and triage/transport decisions. The template to create these guidelines was the Guidelines for Pre-Hospital Management of Traumatic Brain Injury. Similar content areas are discussed in both documents; however, operational concerns are incorporated into the field guidelines which have more relevance for the military community.

Assessment of a head trauma casualty in theatre should include oxygenation and blood pressure evaluation. Neurological assessment should include obtaining a GCS score as well as the assessment of pupils. A single episode of hypotension can worsen the outcome of a severe TBI by causing secondary ischemic insults to the brain.¹² Support of arterial blood pressure is a central tenet of TBI management as hypotension is a powerful predictor of outcome and the only one of the five prognostic indicators that is responsive to therapy.¹² Therefore, avoidance of hypoxemia and hypotension are two primary goals of care in the immediate post-injury period. Pulse oximetry should be used as soon as it is possible within the evacuation chain. Oxygen saturations below 90% should be addressed as soon as resources and the tactical situation allow; and hypotension, defined as systolic blood pressure below 90mmHg, should be avoided. Adequate cerebral perfusion is important in stabilizing a head trauma casualty. Cerebral perfusion is partly based on an adequate systemic blood pressure.

Comprehensive neurological assessment in the field may be difficult to perform. However, GCS score and pupillary assessment should be done by direct clinical examination by a far forward first medical responder as soon as tactically possible. GCS score and pupils should be reassessed prior to the service member moving to the next level of care.

Treatment in the field may consist of airway stabilization, fluid resuscitation, pain management, and brain specific therapies. Airway management is critical in the TBI patient because of the risk of loss of consciousness impacting the ability to protect one's airway. In addition, because the brain does not store oxygen and glucose, the two fuels needed to function properly, the need to maintain adequate cerebral perfusion requires constant oxygenation. Airway, ventilation, and oxygenation are thus crucial. Intravenous fluids may be used to ensure an adequate systemic blood pressure. However, there is inadequate clinical outcome data to support one resuscitation fluid choice over another in the TBI patient. Hypertonic saline and colloids offer logistical advantages over isotonic crystalloids in an austere environment.

Pain management in the TBI patient is difficult because of the desire to preserve a reliable neurological exam. The use of sedatives and analgesics in the TBI patient may cloud or hamper efforts to obtain the best GCS score. The Guidelines¹¹ suggest refraining from administering analgesics for short periods of time in the field, where monitoring is unavailable, to TBI patients who are unable to provide a pain assessment. Brain targeted therapies, such as Mannitol or hypertonic saline are appropriate in the presence of brain herniation. Herniation is the abnormal protrusion through a natural opening. Brain herniation occurs when the intracranial pressure escalates to a point that the brain tissue, due to increased intracranial pressure (ICP), will protrude through the foramen magnum, thus compressing the brainstem. Some indicators of brain herniation may include an unresponsive (no eye opening or verbal response) casualty with unilaterally or bilaterally dilated unresponsive pupils or asymmetric pupils as well as a motor response of abnormal extension (decerebrate or decorticate posturing – they indicate completely different levels of brain injury) or no motor response to painful stimulation.

Triage and transport decisions are based on the tactical environment in which the injury has occurred. Patients with a GCS score between nine and thirteen should be evacuated from the field; however, this can be delayed when an emergent evacuation for a patient with a lower GCS score between three and eight is required. Severe TBI patients, as defined by a GCS score between three and eight, are the most critical. Decisions should be made with caution about those who are considered expectant. GCS scores obtained during an acute evaluation, may overestimate the severity of intracranial injury. Additionally, GCS data may underestimate the capacity for recovery of war fighters, a population who, at baseline, is likely younger and more-fit than the average civilian patient. Depending on available resources and tactical considerations, every

effort should be made to evacuate troops with severe TBI immediately.

In the severe TBI population, there are certain prognostic indicators for recovery that have been studied and reported out in the literature. They include GCS score, age, pupillary diameter and light reflex, hypotension, and CT scan findings.¹¹ If the GCS score is reliably obtained, i.e., in the absence of hypotension, paralytics, or positive toxicology screen, approximately 20% of those with a GCS score of three or four will survive and eight to ten percent will have a functional outcome. In terms of age, children have better outcomes than adults. There is a significant increase in bad unfavorable outcomes above 60 years of age. In performing a pupillary assessment, hypotension and hypoxia should be corrected before using the pupils as a prognostic indicator. The duration of pupillary dilation and fixation should be documented for outcome. A fixed pupil is defined by the absence of constrictor response to bright light. Hypotension, which has been mentioned previously as an important index to correct, is a powerful predictor of outcome and the only one of the five factors that is responsive to therapeutic, non-surgical interventions. The findings on head CT scan are important to assess for prognostic values. The presence or absence of intracranial lesions, the status of the basal cisterns, and presence of a midline shift greater than 1mm are all important indicators of the severity of injury and the likelihood of recovery.

Far forward medical assessment and treatment of moderate and severe traumatic brain injury is crucial to the survivability and recovery of the combat wounded war fighter. The evidence-based guidelines discussed above offer sound recommendations to medics and corpsmen as they care for the most severely injured. Rapid interventions to promote oxygenation and stabilize blood pressure are essential. These injuries also require astute assessments with sound clinical judgment from the earliest stages. Unfortunately, variable medical assets and uncertain tactical environments sometimes complicate the delivery of such care for the severe TBI patient. In situations where an acute TBI may have been missed, it is important to conduct a neurological assessment and provide treatment as soon as possible. Delays in the initial treatment of brain injury reduce the chances for optimal recovery.

MODERATE AND SEVERE TBI CARE AT MILITARY TREATMENT FACILITIES

The moderate TBI patient may require a broad continuum of care. While there are evidence based guidelines for the care of the severe TBI patient⁷ there are no national standards or guidelines developed for the care of the moderate TBI patient. Individual injury characteristics influence the level of care and amount of resources necessary to

optimize ultimate functional status. As with the severe TBI patient, optimizing blood pressure and oxygenation is crucial in the acute stages of injury. It is also important to conduct frequent neurological assessment to detect any subtle changes in level of consciousness or coma. The moderate TBI patient may or may not be in a coma.

One of the hallmark features of patients who incur a moderate TBI is agitation.¹³ Therefore, sedation is sometimes necessary to control extreme agitation that may be harmful to the patient. In addition, environmental and behavioral strategies may be employed to help decrease agitation in a moderate TBI patient. Sedation use in traumatically brain injured patients can impose difficult clinical implications if the neurological exam is altered. Therefore, behavioral strategies such as the establishment of sleep/wake cycles, reorientation to self, place, and time, as well as implementing a structured schedule, may all be of benefit when trying to manage agitation.¹⁴ In addition, environmental strategies such as the regulation of auditory, sensory, and tactile inputs, in a patient who may not be able to process all inputs, may be of benefit. Removing noxious stimuli for this patient population is also helpful. Limiting external stimulation such as the television, radio, and other sensory irritants may also help decrease the outward signs of agitation commonly found in the acute care setting. The therapeutic regiment for the management of agitation should be tailored to the individual needs of the patient with consideration of the external environment.

The severe TBI patient may require complex interventions to help facilitate recovery. Control of increased ICP should be the main focus of care. There are medical and surgical treatment strategies that are specifically aimed at the preservation of oxygen and glucose delivery to the brain. In addition, because the skull is a rigid, fixed vault there is little additional room for expansion and compliance when the brain swells after injury. Therefore, monitoring and treating ICP after severe brain injury is paramount. Surgical treatments to combat increased ICP may involve a craniotomy or craniectomy. Both procedures may decrease ICP by addressing the expanding lesion, whether it is a hematoma, contusion, or edema. During craniectomy, the bone flap is removed and is not replaced at the end of neurosurgical intervention. This is performed to allow possible brain herniation through a bony defect that is created during surgery as opposed to brain herniation onto the brainstem, which is incompatible with life.

There are many medical treatment modalities available to help alleviate increased intracranial pressure in a severe TBI patient. These include, but are not limited to, the use of cerebrospinal fluid (CSF) drainage via ven-

triculostomy, hyperosmolar agents such as hypertonic saline or Mannitol, sedation and paralytic agents, barbiturates, and others.⁷ Intracranial pressure monitoring is crucial in this population because it allows for a dynamic evaluation of ICP as well as a gauge to evaluate the effectiveness of various treatment modalities. A ventriculostomy is considered the gold standard for ICP monitoring because it allows for both monitoring and drainage of CSF.⁷

Many other types of care are necessary to adequately assess and treat those who have critical brain injuries. Attention to nutrition, skin, and other body systems is important. Severe TBI patients are also at risk for numerous complications including seizures, pulmonary embolus, deep vein thrombosis, infection, sepsis, and electrolyte imbalances, just to name a few. In addition, moderate and severe TBI patients usually have altered mental status including coma and are unable to communicate their needs to their care providers, which makes addressing their medical concerns much more difficult.

CARE SYSTEMS FOR SERVICE MEMBERS AND VETERANS

While TBI may result in significant physical impairment, often the more problematic consequences of brain injury involve the individual's cognition, emotional functioning, and behavior. These can impact all aspects of life including the development or maintenance of interpersonal relationships with others. Following stabilization and medical evacuation from theater, there are a wide variety of clinical and rehabilitative resources available to service members. The particular resources used will depend upon the severity of the injury, the clinical presentation of the patient, and the extent of recovery during the initial intervention and stabilization.

In order to optimize recovery, inpatient rehabilitation commonly begins at a VA polytrauma center in Palo Alto, CA; Minneapolis, MN; Richmond, VA; or Tampa, FL. Each site is accredited by the Commission on the Accreditation of Rehabilitation Facilities and is staffed by a multidisciplinary team of clinicians who are trained to treat patients with moderate to severe brain injuries.¹⁵ Since their designation as Polytrauma Rehabilitation Centers by the VA in 2005, these sites have also been resourced to treat brain-injured patients with other combat injuries.¹⁶ This has been an important expansion of services as many of our warfighters sustain multiple traumatic injuries in theater and require simultaneous care for a variety of clinical and rehabilitative needs such as brain injury, amputation, and wound care. In this way, for example, both brain injury rehabilitation and physical therapy with training using a prosthetic device can happen at the same time, contingent upon the tolerance and ability of the individual pa-

tient. Co-treatment plans are common within the context of TBI rehabilitation.

Inpatient TBI rehabilitation at these four polytrauma centers comprises comprehensive interdisciplinary evaluation and treatment of brain injury sequelae as well as treatment of secondary complications and concomitant injuries. Rehabilitation services are provided by an interdisciplinary team of clinical specialists which may include the following professionals: physiatrist; neuropsychologist; physical, occupational, and recreation therapists; speech therapist; low vision specialist; nurse; social worker; and vocational rehabilitation counselor. Inpatient rehabilitation may also offer services such as coma stimulation or neurobehavioral management (described on previous page) for patients who require it. The structure of an inpatient rehabilitation stay is dictated by the particular patient's clinical needs and their responsiveness to the rehabilitation itself.

The scope and course of an individual patient's TBI rehabilitation treatment plan will be tailored to their specific deficits, using their particular capacities at the time of admission. It is generally expected that, for a patient to engage with a rehabilitation program fully, they will be able to tolerate three to four hours of intensive therapy per day at the time of their admission. These therapies, as previously noted, might include physical therapy, occupational therapy, kinesiotherapy, and/or speech and language therapy. For a patient whose brain injury limits physical and cognitive functioning, this kind of regimen can be extremely tiring. For those who are able to tolerate more, treatment plans will be adjusted to reflect their individual capacities and to challenge them as appropriate to meet their level of therapeutic benefit. In addition, neurobehavioral management is available for those moderate to severe TBI patients whose deficits may have resulted in behavioral dysfunction. Behavioral problems following brain injury may be the result of the organic brain injury itself or an inability of the compromised brain to adequately assimilate external stimuli or negotiate novel situations.

The VA polytrauma centers also offer services and therapies to patients who enter at a much lower level of functioning. This would include service members who are minimally responsive, do not follow simple commands, or do so intermittently. Sometimes it is difficult for family members to understand the severity of these injuries as it is not uncommon for severe TBI patients to have their eyes open and to appear to track figures across the room, despite their inability to follow verbal commands. These patients are genuinely unable to engage with their environment. Coma stimulation programs may include physical therapy to exercise a patient's physical

body or sensory stimulation to introduce external stimulation to engage fundamental receptor responses in the brain.

The length of stay in an acute program will vary depending upon the initial deficits of the individual, their overall medical needs, their progress during rehabilitation, and their responsiveness to different treatments. An overall average length of stay for a moderate or severe TBI patient may span between three and six months, with an average of four months following emergence from coma.¹⁷ For patients whose recovery does not progress significantly during the course of their acute rehabilitation, there are post-acute programs where they may continue their rehabilitation. These kinds of programs include assisted living facilities and skilled nursing facilities. An assisted living facility would be appropriate for an individual who needs ongoing assistance with activities of daily living such as meal preparation and some of the tasks of daily living, but does not require advanced on-site medical care. A skilled nursing facility would be appropriate for an individual who does need on-site medical care in addition to assistance with most of the activities of daily living. In some cases, home nursing care is provided for patients enabling them to return to their family and community where they may receive medical support as needed in their home.

The ultimate goal of any rehabilitation program is to return the individual to the community to pursue as full and rich a life as possible. For individuals who are able to leave an acute inpatient TBI rehabilitation stay and progress towards rejoining a community more independently, a community re-entry program may be indicated. This broad term includes various kinds of programs and may include residential transitional living facilities, home care services, or vocational rehabilitation programs. The kind of community that a brain-injured patient may return to, again, will be dictated by their course of recovery and their clinical presentation. For some, the community they return to may be their military installation as they return to full active duty status. Others may reenter the civilian community as a veteran.

CONCLUSION

Traumatic brain injury is the signature injury of current conflicts. Tactical combat casualty care plays an integral part in triaging and treating combat wounded troops with life threatening injuries. Far forward medical assessment and treatment of moderate and severe traumatic brain injury is crucial to the survivability and recovery of combat wounded warfighters. The information and strategies that have been described are intended as an overview to assist medics and corpsmen as they care for the most severe TBI patients. For a more complete step by step guide to TBI care please refer to the "Guideline for

Field Management of Combat Related Head Trauma." Quick reference guides to the assessment and management of severe TBI are also available from the Brain Trauma Foundation. An optimal outcome can be achieved when these principals are applied with rapid medical evacuation, care coordination, and comprehensive rehabilitation. While the long-term effects of acute brain injury may be significant, there is often potential for considerable improvement which allows patients with brain injury to lead meaningful and productive lives.

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